Lecture 9 - Perfect Competition

ECON 3070 - Intermediate Microeconomic Theory

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Overview

In this chapter, we will:

- Define a perfectly competitive market.
- Discuss the difference between economic profit and accounting profit.
- Learn how to calculate a firm's optimal input combination for profit maximization.
- Consider both short-run and long-run profit-maximization

Perfectly Competitive Markets

Perfectly competitive markets have 4 defining characteristics:

1. Fragmented market - many buyers and sellers
2. Undifferentiated products (e.g. oil, corn, soybeans).
3. Consumers have perfect information about prices of all sellers
4. Equal access to resources - same technology, access to same inputs

Perfectly Competitive Markets

These characteristics have 3 implications:

1. Buyers and sellers are price takers
2. Law of one price - demand is perfectly elastic
3. Free entry and exit - If market is profitable, firms enter. If unprofitable, firms exit.

This final implication implies that profits equal zero

Economic & Accounting Profits

What do I mean by zero profits? Why would anyone start a company in a perfectly competitive market if they're guaranteec to make 0 profits!!

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Remember that economic costs = explicit costs + implicit costs (such as the opportunity cost of not working a job)

- **Economic profit** = Sales Revenue - Economic Costs
- **Accounting profit** = Sales Revenue - Accounting Costs

When we discuss profit maximization, we mean economic profit.

Try It Yourself

Suppose that Tom, a lawyer quits his job to start a lawn care company. Before he quit, the lawyer was earning \$120,000 per year (which he could return to at any time). With the lawn care company, Tom expects his revenue to be \$300,000 per year. He expects his annual cost of wages for workers to be \$80,000, and additional operating costs to be \$20,000. Additionally, Tom invested \$80,000 in equipment, money which he could have otherwise invested in the stock market, with a return of \$5,000 per year. Find Tom's economic profit.

Profit Maximization

Remember that a firm's profit function looks like

$$\pi = P * Q - TC(Q, w, r)$$

where $P * Q$ is equal to total revenue, $TR(Q) = PQ$.

- $TC(Q, w, r)$ is the total cost function that we looked at in chapters 7 and 8.
- Because the firm is a price taker, P doesn't depend on how many units the firm sells.

Profit Maximization

A profit-maximizing perfectly competitive firm chooses the quantity Q which maximizes profit.

In other words, the firm's problem is

$$\max_{Q} \pi(Q) = PQ - TC(Q, w, r)$$

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If we take the partial derivative of this equation with respect to Q and set it to zero, we find the quantity that maximizes profit.

$$P - \frac{\partial TC(Q, w, r)}{\partial Q} = 0 \Rightarrow P = MC(Q, w, r)$$

Profit Maximization

In words, the firm will produce output until the revenue it receives from an additional unit (P) equals the marginal cost of producing that unit ($MC(Q)$).

- The revenue that it receives from an additional unit of output is called **marginal revenue**.
- That is, Q is chosen such that $P = MR = MC$.

Profit Maximization

Here's the intuition: After some point, MC is increasing. As long as a firm can sell a unit for more than it's marginal cost, $P > MC(Q)$, it should keep selling more units.

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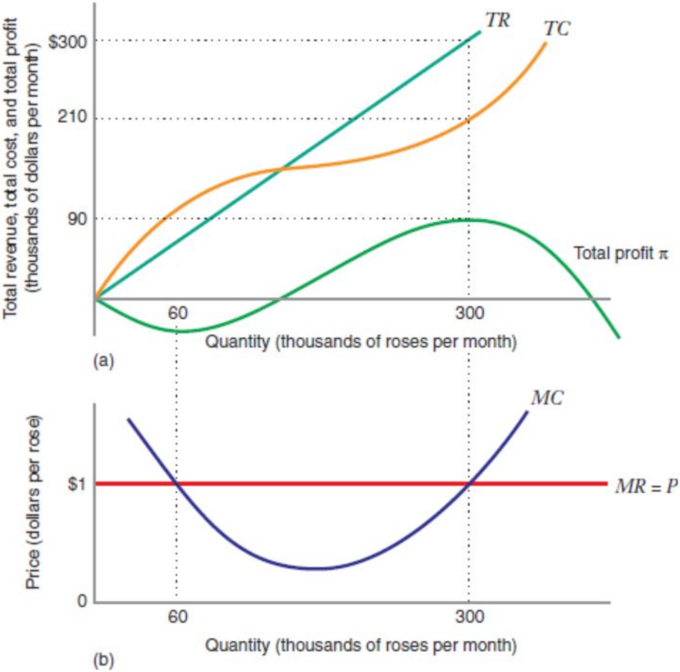
$\implies$ profit is maximized where $P = MC(Q)$.


TR
TC
$300
210
90
Total profit π
60
300
Total revenue, total cost, and total profit (thousands of dollars per month)
Quantity (thousands of roses per month)
(a)
MC
$1
MR = P
0
60
300
Price (dollars per rose)
Quantity (thousands of roses per month)
(b)

Profit Maximization

Once you have found the marginal cost function, all you need to do is solve $P = MC(Q, w, r)$ for Q.

Either you will be given

1. $TC(Q)$, or
2. will have to derive it from a production function $Q(K, L)$

Example

Suppose a firm's total cost function is given by

$$TC(Q, w, r) = 2wQ^2 + 8r$$

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Solving for Q:

$$P = 4wQ \Rightarrow Q^* = \frac{P}{4w}$$

Profit Maximization

Now that we know $Q^*(P, r, w)$, we can plug that back into our conditional input demand functions for capital and labor and find our **unconditional input demand functions**.

- These functions do not condition on a given level of quantity $\bar{Q}$.
- Instead, they implicitly reflect how Q will change as P changes, in order to maximize profit.

Profit Maximization

Another way that we can find the firm's profit maximizing output quantity is by writing total cost as a function of L and K:

$$Q = f(K, L) \text{ and } TC(Q, w, r) = wL + rK$$

Plugging those into the firm's profit function, the firm's problem then becomes:

$$\max_{L,K} \pi = P * f(K, L) - wL - rK$$

Profit Maximization

$$\max_{L,K} \pi = P * f(K, L) - wL - rK$$

Again using unconstrained optimization, we can find the two first-order conditions:

$$\frac{\partial \pi}{\partial L} = P\frac{\partial f}{\partial L} - w = 0 \Rightarrow P = \frac{w}{MP_L}$$
$$\frac{\partial \pi}{\partial K} = P\frac{\partial f}{\partial K} - r = 0 \Rightarrow P = \frac{r}{MP_k}$$

Profit Maximization

If we combine the two first-order conditions, we get the following **optimality condition** for price maximization:

$$P = \frac{w}{MP_L} = \frac{r}{MP_k}$$

The second part of this looks a lot like our optimality condition for cost minimization.

That's because maximizing profit requires producing at the lowest cost.

Profit Maximization

If we rearrange our first-order conditions in a different way:

$$P * MP_L = w \text{ and } P * MP_K = r$$

This tells us that the cost of an additional unit of capital or labor should equal the revenue that it generates.

At the optimal output level the price of the output good should equal the amount of money it costs to produce the last unit with either labor or capital. That is,

$$P = MC(Q)$$

Example

Suppose that a firm has the production function $Q(K, L) = 20K - K^2 + 16L - L^2$ with $MP_L = 16 - 2L$ and $MP_K = 20 - 2K$.

Our optimality condition says that

$$P = \frac{w}{16 - 2L} \text{ and } P = \frac{r}{20 - 2K}$$

Example

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We can solve for K in the second equation, and find that

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Doing the same with the first equation, we find that

$$16 - 2L = \frac{w}{P} \text{ or } L^*(P, w, r) = 8 - \frac{w}{2P}$$

Profit Maximization

Once we've found the unconditional input demand curves, we can now solve for the optimal production function: $Q^*(P, w, r)$.

That is;

$$Q^*(P, w, r) = Q\big(K^*(P, w, r), L^*(P, w, r)\big)$$

Try It Yourself

Suppose that a profit-maximizing firm has the production function $Q(K, L) = 30K - \frac{1}{2}K^2 + 40L - \frac{1}{2}L^2$, with $MP_L = 40 - L$ and $MP_K = 30 - K$. Find the firm's unconditional labor demand function.

Short-Run Profit Maximization

Suppose that K is fixed ($K = \bar{K}$) in the short run.

Can solve profit maximization problem with one variable input.

$$\max_{L} \pi(P, r, w) = PQ(L, \bar{K}) - wL - r\bar{K}$$

FOC:

$$P * \frac{\partial Q(L, \bar{K})}{\partial L} - W = 0 \Rightarrow P = \frac{w}{MP_L}$$

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FOC:

$$P * \frac{\partial Q(L, \bar{K})}{\partial L} - W = 0 \Rightarrow P = \frac{w}{MP_L} \Rightarrow P = SMC(Q, w)$$

No cost minimization condition, because there is only one way to produce Q units.

Deriving the Firm's Supply Curve

The solution to the firm's problem gives us the firm's supply function:

$$Q^*(P, w, r)$$

If w and r are fixed, can plot firm's supply curve in P-Q space.

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Recall the profit maximizing condition under perfect competition in the short run: $P = SMC(Q)$

- Inverse supply curve is the short-run marginal cost curve (you give me Q, I give you $SMC(Q)$)

Deriving the Firm's Supply Curve

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Suppose the firm has large fixed costs that could be recovered if firm sets $Q = 0$ (e.g. electricity costs)

Perhaps even at profit-maximizing quantity, profits do not offset total fixed costs (TFC).

- Then $Q = 0$ is optimal.
- Will occur if market price of final good is low enough.

Deriving the Firm's Supply Curve

If firm is making positive profit when $Q > 0$, must be making positive *per-unit* profit

- Because all units sell at price P, that means that average variable cost is below the price $P > ATC(Q)$.
- If $P < \min(ATC(Q))$, firm will produce $Q = 0$ in the long-run.

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The price at which $P = \min(ATC(Q))$ is called the **break-even price**

Deriving the Firm's Supply Curve

In the short-run, the fixed costs are already paid for (sunk costs). Therefore, 'short-run profit' is the difference between market price and *average variable cost*.

The reason is if price is above AVC, then you can pay off some of your sunk costs.

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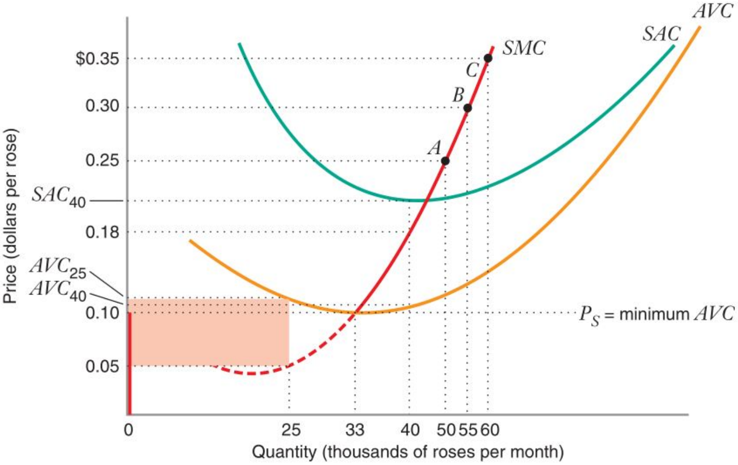
The price at which $P = \min(AVC(Q))$ is called the **shut-down price**

Deriving the Firm's Supply Curve



Short-Run Market Supply

Once we have each firm's supply curve, we can find the market supply curve. The market supply curve tells us the quantity supplied by *all firms* at any given price.

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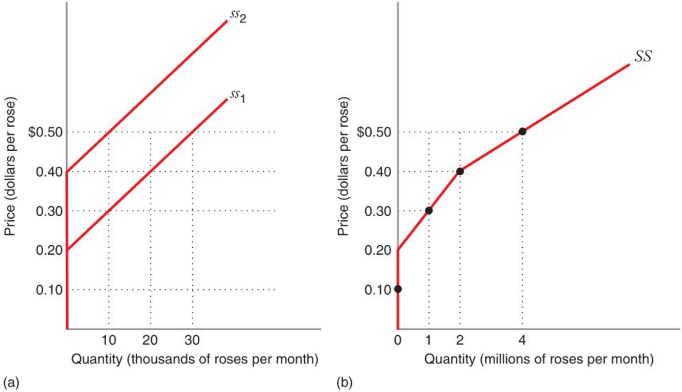
As we saw in chapter 2, the market supply curve is found by horizontally summing every firm's supply curve.

- Only works if input prices are constant (don't depend on level of output).
- Might be true for some inputs (such as unskilled labor), but not necessarily for others (such as very-skilled labor like PhD economists)

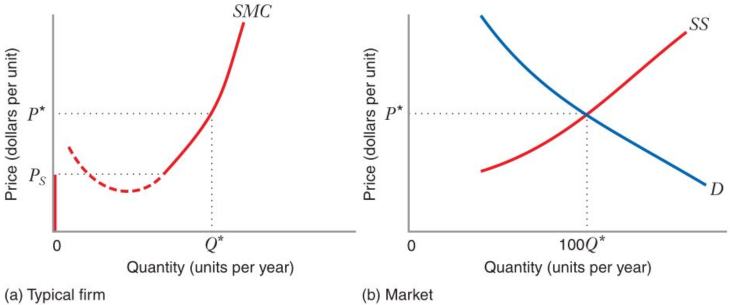
Short-Run Market Supply



Short-Run Perfectly Competitive Equilibrium

Now that we have a market supply curve, we can find the **short-run perfectly competitive equilibrium**.

- That is, the price at which quantity supplied equals quantity demanded.



Try It Yourself

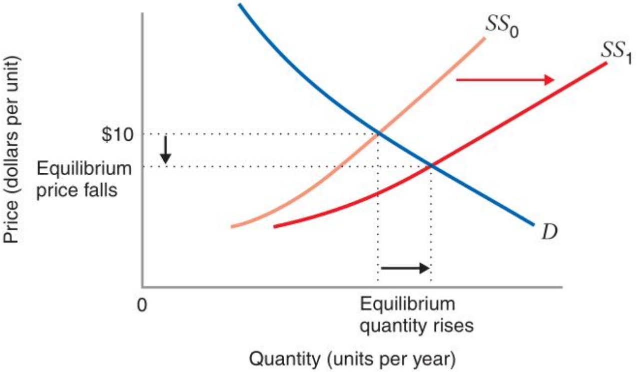
Suppose that a market is made up of 300 identical firms, each with short-run total cost curve $STC(Q) = 0.1 + 150Q^2$, and corresponding marginal cost $SMC(Q) = 300Q$ and average variable cost $AVC(Q) = 150Q$. If market demand for the good is $D(P) = 60 - P$, find the market equilibrium, assuming that all firms will supply at any price.

Comparative Statics Analysis

Suppose that the number of firms in a market increases (for example, suppose a large number of new oil refineries were built).

- This will shift the supply curve to the right.
- In chapter 2 we learned that if this happens, equilibrium *price* will fall, and equilibrium quantity will rise.

Comparative Statics Analysis



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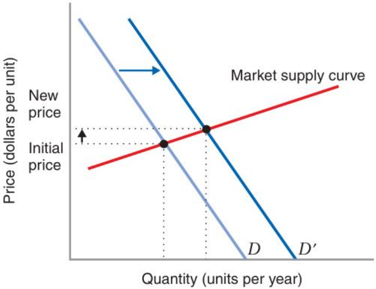
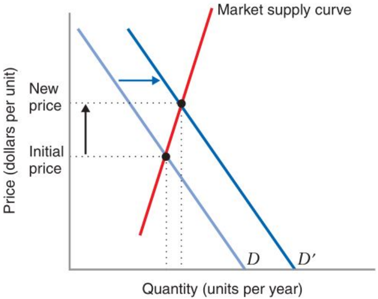
The magnitude of these changes depends on how responsive supply is to a change in price.

- If suppliers can't change their output level easily (inelastic supply), then price might rise by a lot (e.g. corn farmers).
- If suppliers can easily change their output level (elastic supply), then price might not rise by much, and quantity sold increases (e.g. hair salon).

Comparative Statics Analysis



(a) Effect of shift in demand:
Supply is relatively elastic



(b) Effect of shift in demand:
Supply is relatively inelastic

Try It Yourself

Suppose that in the Denver pizza market, the market supply curve is perfectly elastic. If people decide that pizza causes cancer, and demand falls, what will be the short-run effect on the equilibrium price and quantity?

A) Price increases, quantity decreases
B) Price decreases, quantity decreases
C) Price unchanged, quantity decreases
D) Price unchanged, quantity increases

Long-Run Equilibrium

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In the long-run, however, firms can enter or exit, which drives profit to zero.

- If per-unit profits are positive, firms enter the market and lower the price and hence the per-unit profit margin
- If per-unit profits are negative, firms exit the market and raise the price and hence the per-unit profit margin

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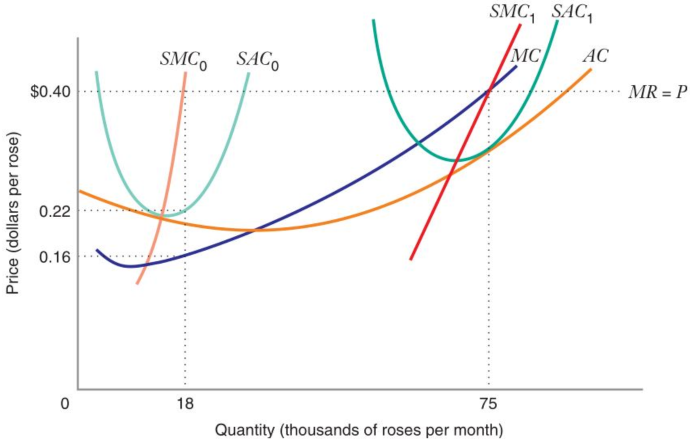
Firms in the long-run can also adjust plant size (and other fixed inputs), leading to new short-run cost curves.

Long-Run Equilibrium



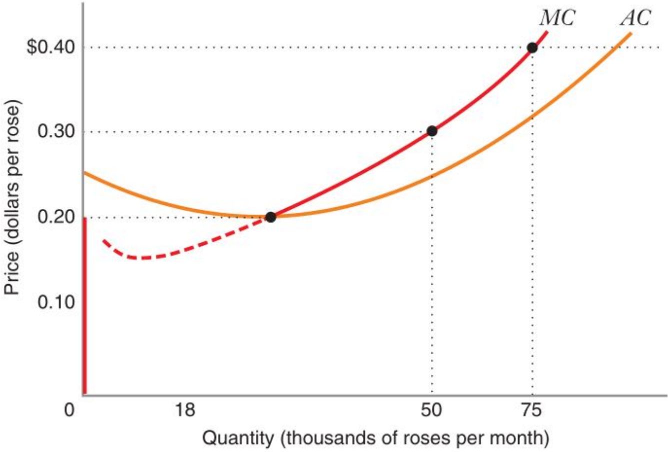
The Firm's Long-Run Supply Curve

Similar to the short run, the firm's long-run supply curve is equal to it's LRMC curve, for most prices.

- But only if the firm is earning positive profit overall ($\pi \geq 0$).
- That is, only if $LRAC \geq P$

If the firm isn't earning positive profit, it will exit the market in the long run (raising the market price).

The Firm's Long-Run Supply Curve

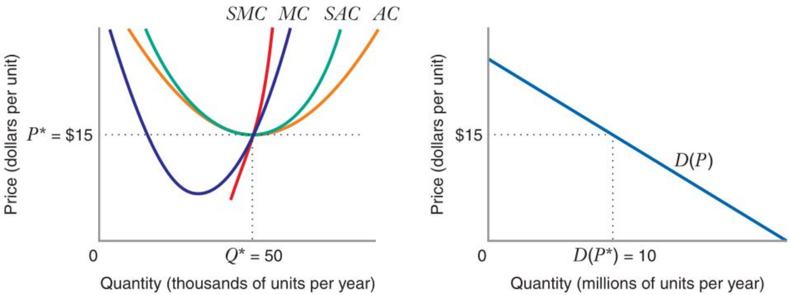


Long-Run Market Equilibrium

- If per-unit profits are positive, $P^* \geq AC(Q^*)$, firms enter the market and lower the price and hence the per-unit profit margin
- If per-unit profits are negative, $P^* \geq AC(Q^*)$, firms exit the market and raise the price and hence the per-unit profit margin

This drives long-run profits toward zero where $P^* = AC(Q^*)$.

Long-Run Market Equilibrium



(a) Typical firm

(b) Market

Long-Run Market Equilibrium

We can define the long-run perfectly competitive equilibrium as follows:

- Each firm chooses Q^* to maximize long-run profit, or $P^* = MC(Q^*)$ (zero profit).
- Each firm's economic profit is zero, or $P^* = AC(Q^*)$
- Market demand equals market supply at the equilibrium price, or $Q_D^*(P^*) = Q_S^*(P^*)$.

Example

Suppose that a market is composed of identical firms. Each firm has long-run cost curve $AC(Q) = 40 - Q + 0.01Q^2$ and corresponding marginal cost curve $MC(Q) = 40 - 2Q + 0.03Q^2$.

The market demand curve is given by $D(P) = 25,000 - 1000P$. Find the long-run equilibrium quantity and market price.

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The first two equilibrium conditions, $P^* = MC(Q)$ and $P^* = AC(Q)$, imply that $MC(Q) = AC(Q)$. That is,

$$40 - Q + 0.01Q^2 = 40 - 2Q + 0.03Q^2$$

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$$40 - Q + 0.01Q^2 = 40 - 2Q + 0.03Q^2 \implies Q^* = 50$$

Example

We can plug the firm's optimal quantity in to find their MC, and thus, the market price.

$$P^* = MC(Q^*) = 40 - 2 * 50 + 0.03 * 50^2 = 40 - 100 + 2,500 * 0.03 = 15$$

Example

We can plug the firm's optimal quantity in to find their MC, and thus, the market price.

$$P^* = MC(Q^*) = 40 - 2*50 + 0.03*50^2 = 40 - 100 + 2,500*0.03 = 15$$

At a price of $15, consumer demand is given by

$$D^*(P^*) = 25,000 - 1000*15 = 10,000$$

Example

Finally, we need to find the equilibrium number of firms needed to supply 10,000 units. That is,

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$$Q_D^*(P^*) = n^* Q_{firm}^*(P^*) \implies n^* = 10,000/50 = 200.$$

Long-Run Market Equilibrium

Therefore, in this market, the long-run equilibrium can be defined as follows:

$$
\begin{aligned}
P^* &= 15 \\
Q^*_{firm} &= 50 \\
n^* &= 200
\end{aligned}
$$

Try It Yourself

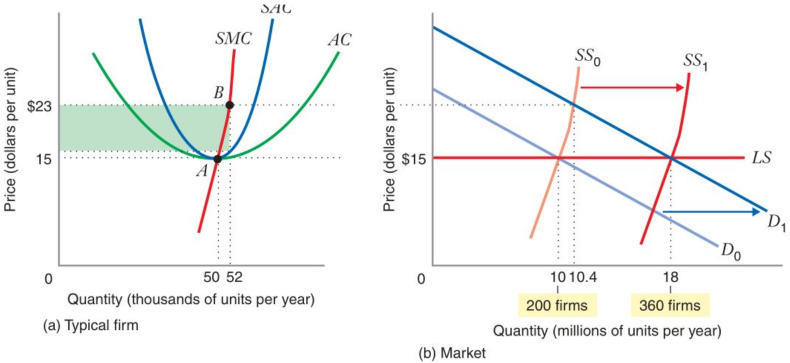
Suppose that consumer demand has increased, such that $D(P^*) = 30,000 - 1,000P^*$. Find the new long-run equilibrium number of firms.

Long-Run Market Supply Curve

The **long-run market supply (LS) curve** tells us the total quantity of output that will be supplied at every price, assuming that all long-run adjustments have taken place.

- In other words, the long-run market supply curve traces the equilibria that result from increases in demand.

Long-Run Market Supply Curve



Constant-, Increasing-, and Decreasing-Cost Industries

In the previous section, we assumed that new entry doesn't affect the price of inputs.

This may be the case when an industry's demand for an input is a small part of overall demand for that input (i.e. unskilled labor, electricity, etc...)

- When changes in an industry's output have no effect on input prices, we call it a **constant-cost industry**.

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This may be the case when an industry's demand for an input is a small part of overall demand for that input (i.e. unskilled labor, electricity, etc...)

- When changes in an industry's output have no effect on input prices, we call it a **constant-cost industry**.

However, when expansion of an industry increases the price of an input, it is an **increasing-cost industry**.

- If an industry uses **industry-specific inputs**, they are likely to be an increasing-cost industry (e.g pharmacists).

Constant-, Increasing-, and Decreasing-Cost Industries

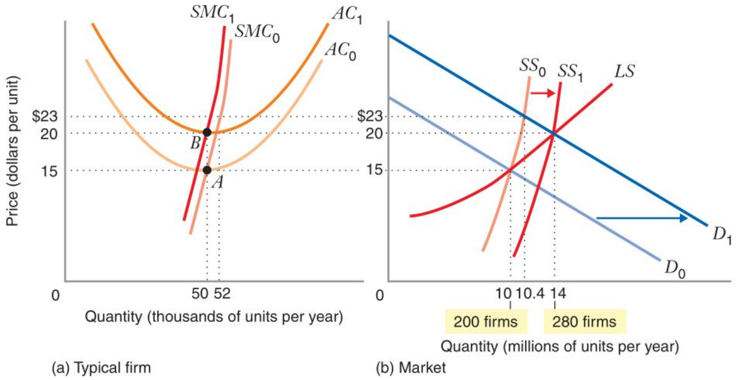
When more firms enter in an increasing-cost industry, marginal costs increase for all firms in the industry.

- It costs a firm more to produce a given quantity than before.
- Thus, minimum average cost increases.

As before, firms continue to enter until $P = \min(AC)$.

- But now $\min(AC)$ is greater than before, so the long-run equilibrium price has gone up.
- =Thus, the long-run supply curve is upward sloping.

Constant-, Increasing-, and Decreasing-Cost Industries



Constant-, Increasing-, and Decreasing-Cost Industries

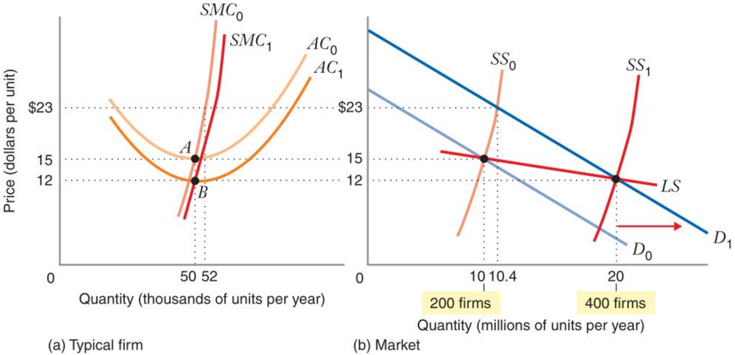
For other industries, input prices may decrease as industry output increases.

- This can be the case if the input producers can take advantage of economies of scale (computer chips, for example).

In this case, as firms enter, marginal costs fall for individual firms.

- And in the long-run, the price settles at the new, lower minimum average cost.
- Thus, the long-run supply curve is downward-sloping.

Constant-, Increasing-, and Decreasing-Cost Industries



Producer Surplus

When a firm sells a product, they often sell some of the units at a higher price than they would have been *willing to* sell them at.

This difference is called **producer surplus**.

- Graphically, it is the area of the supply and demand graph below the market price, but above the firm's supply curve.
- It is analogous to consumer surplus in consumer theory.

Producer Surplus

What if a firm faces a fixed cost in the long-run (e.g. rent and machinery)?

- Then below some price, they may not be willing to supply any quantity below a certain price.
- Below this shutdown price, consumer surplus would be zero (as the firm would not supply any of the good).

Some markets don't exist even though there is potential demand for it(!)

Try It Yourself

Suppose that the market supply curve for milk is given by $Q = 60P$ (assume that there are no fixed costs), where Q is the quantity of milk sold per month (measured in thousands of gallons) when the price is P dollars per gallon. What is the producer surplus when the price of milk is \$3 per gallon?